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Atlas of Probabilities of Surface Temperature Extremes:
Part I—Northern Hemisphere

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16 April 1976

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is approved for publication.

FOR THE COMMANDER:

John Howard
Chief Scientist

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A method for calculating warm (cold) temperature extremes during the warmest (coldest) month of the year was developed. Regression analyses were performed for warm (cold) temperature versus an index calculated from a station's monthly mean temperature and mean daily range. Correlation for these regression lines ranges from 0.974 to 0.995. Warm and cold indices, calculated for approximately 2000 Northern Hemisphere stations, were plotted and analyzed. The resulting Northern Hemisphere maps of the 1-, 5-, and → next page

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20. Abstract (Continued)

10-percent warm temperatures, and the 1-, 5-, 10-, and 20-percent cold temperatures for the warmest (coldest) month are presented.

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Preface

The authors wish to express their appreciation to Ms. Melinda Zouvelos for her efforts in preparing the data and laboriously plotting the percentile maps for analysis. Her performance in completing numerous calculations and otherwise processing the data was outstanding.

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Atlas of Probabilities of Surface Temperature Extremes: Part I—Northern Hemisphere

1. INTRODUCTION

Military Standard Climatic Extremes for Military Equipment, MIL-STD-210B, established uniform climatic design criteria for military materiel intended for world-wide use (excluding the air, land, and ice shelf areas south of 60°S). The Air Force Geophysics Laboratory (AFGL) recognized the limitations of MIL-STD-210B in meeting the requirements for climatic information for design of systems not intended for world-wide use. Accordingly, plans were formulated in FY75 to prepare a world atlas of climatic contour maps to enable the designer to ascertain climatic extremes for any particular geographic area of concern.

This report provides percentile maps of surface temperature for the land areas of the Northern Hemisphere. To be published in the near future, Part II of this report will provide analogous information for the Southern Hemisphere. The percentiles conform to the basic risk philosophy used to determine operational design values for MIL-STD-210B: that is, equipment should operate during extremes that are exceeded for a small percentage of time during the worst month of the year in the geographic area of interest.

In MIL-STD-210B, the extreme exceeded 1 percent of the time during the worst month (the 1-percent temperature) is used as the design criterion for all but two climatic elements. One of these is the surface cold temperature for which the

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20-percent extreme is used.[1] For surface warm temperatures, MIL-STD-210B prescribes that equipment should operate with a 1-percent risk of inoperability during the worst month of the year.

Most previous studies of temperature for design (for example, Tattelman et al,[2] Billions,[3] Salmela et al,[4] Gringorten et al,[5] Tattelman,[6] Gringorten,[7] Williams,[8] and Bennett[9]), some of which were used to determine the warm and cold temperature criteria for MIL-STD-210B, directed attention only to the most severe locations. This study provides extremes for the land surface of the Northern Hemisphere. For cold temperature, maps of temperature equalled or colder 1, 5, 10 and 20 percent of the time during the coldest month (up to +10 C) are presented. For warm temperature, maps of temperature equalled or exceeded during 1, 5, and 10 percent of the time during the warmest month (down to +10 C) are presented.

2. DERIVATION OF TEMPERATURE FREQUENCY RELATIONSHIPS

2.1 Warm Temperatures

The ideal method for determining frequency distributions of temperature would be to obtain actual distributions of hourly temperatures for a long period. These data are readily available for a large number of stations in North America, but on

1. Dept. of Defense (1973) Military Standard Climatic Extremes for Military Equipment, MIL-STD-210B, 15 Dec. 1973, Standardization Division, Office of the Assistant Secretary of Defense (I&L), Washington, D.C. 20305.
2. Tattelman, P.I., Sissenwine, N., and Lenhard, R.W., Jr. (1969) World Frequency of High Temperature, AFCRL-69-0348.
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a world-wide basis, there is an insufficient number of stations with complete, long term (at least 10 years) records to permit an accurate analysis. This difficulty was overcome in an earlier study by Tattelman[2] on the frequency of high temperatures. In that report he determined that high temperatures corresponding to low probabilities are found where the monthly mean temperatures are highest and the mean daily range is greatest. A simple index of these values is expressed by:

$$I_w = \overline{T} + (\overline{T}_x - \overline{T}_n) \quad , \tag{1}$$

where I_w is the warm temperature index, $\overline{T}$ is the mean, $\overline{T}_x$ is the mean daily maximum, and $\overline{T}_n$ the mean daily minimum temperature for the warmest month.

Since good climatic records are readily available for these parameters, it was decided to determine if Eq. (1) is applicable on a more general basis than just the very hot locations for which it was originally used. The index was correlated with each of the observed 1-, 5-, and 10-percent warm temperatures during the warmest month at 30 National Weather Service Stations throughout the contiguous United States (data from Tattelman[2]) plus 13 stations in Europe and the North Atlantic [data provided by (ETAC)]. The stations and pertinent data are listed in Table 1.

The following regression lines for the 1, 5, and 10 percent temperatures were found by the method of least squares:

$$T_{1\%} = 0.753\, I_w + 7.611 \tag{2}$$

$$T_{5\%} = 0.775\, I_w + 4.040 \tag{3}$$

$$T_{10\%} = 0.7821\, I_w + 0.289 \tag{4}$$

Linear correlations are 0.97 for $T_{1\%}$, and 0.98 for $T_{5\%}$ and $T_{10\%}$. The standard errors of estimate are 1.60°, 1.28°, and 1.23°C, respectively. Scatter diagrams and least squares fits are shown in Figure 1.

As an independent check for Eqs. (2), (3), and (4), observed 1, 5, and 10 percent temperatures for several locations (data available from a previous study by ETAC) were compared with the estimated percentile temperatures. These comparisons are shown in Table 2.

Table 1. List of Stations, Showing 1-, 5-, and 10-Percent Warm Temperatures (°C) during the Warmest Month. Also, Mean ($\bar{T}$), Mean Daily Range ($\bar{T}_x - \bar{T}_n$), and Index ($\bar{T} + (\bar{T}_x - \bar{T}_n)$)

Station	Alt (Ft)	Lat	Long	$\bar{T}$	$\bar{T}_x - \bar{T}_n$	Index	$T_{1\%}$	$T_{5\%}$	$T_{10\%}$
U.S.									
Amarillo	3604	35N	102W	27.2	15.0	42.2	37.2	35.0	33.3
Atlanta	976	34	84	26.1	10.6	36.7	36.1	33.3	31.7
Bakersfield	475	35	119	28.9	15.5	44.4	40.6	38.9	37.2
Birmingham	630	34	87	26.7	11.7	38.4	37.2	34.4	32.8
Boston	29	42	71	23.3	9.4	32.7	34.4	31.1	29.4
Brownsville	20	26	97	28.9	9.4	38.3	35.6	33.9	33.3
Caribou	628	47	68	18.3	11.7	30.0	31.1	27.2	25.6
Death Valley	-194	36	117	38.9	16.1	55.0	50.6	48.9	47.2
Des Moines	963	42	94	25.0	12.2	37.2	35.6	32.8	31.1
El Paso	3916	32	106	27.8	14.4	42.2	38.3	36.1	34.4
Fargo	899	47	97	21.7	13.9	35.6	34.4	30.6	28.9
Fresno	327	37	120	27.2	20.6	47.8	40.0	37.2	36.1
Goodland	3688	39	102	25.0	17.2	42.2	38.3	35.6	33.3
Houston	62	30	95	28.3	10.0	38.3	36.7	34.4	33.3
Jacksonville	31	30	82	28.3	10.6	38.9	36.7	34.4	32.8
Laredo	491	28	99	31.1	12.8	43.9	40.6	38.9	37.2
Little Rock	265	35	92	27.8	12.2	40.0	37.8	35.0	33.9
Miami	12	26	80	27.8	7.8	35.6	34.4	31.7	31.1
Minneapolis	838	45	93	22.8	13.3	36.1	35.0	31.7	30.0
New Orleans	30	30	90	27.8	10.0	37.8	34.4	32.8	31.7
Oklahoma City	1304	35	98	27.2	12.2	39.4	38.3	35.6	33.9
Phoenix	1107	33	112	32.8	15.0	47.8	43.9	41.7	40.0
Rapid City	3168	44	103	23.3	15.6	38.9	36.7	33.3	31.7
Sacramento	25	39	122	25.0	20.0	45.0	39.4	36.1	33.9
Salt Lake City	4227	41	112	24.4	17.2	41.6	37.2	34.4	32.8
Sault Ste Marie	724	46	84	18.3	12.2	30.5	30.6	27.2	25.0
Tucson	2584	32	111	30.0	14.4	44.4	41.7	38.9	37.2
Washington	65	39	77	25.6	10.0	35.6	36.1	33.3	31.7
Wichita	1340	38	97	27.2	12.8	40.0	40.6	36.7	35.0
Yuma	206	33	115	34.4	15.6	50.0	44.4	42.2	41.1
Germany									
Bitburg AB	1238	50 N	7 E	16.7	9.2	25.9	30.0	25.6	22.8
Erding AS	1512	48	12	18.4	11.1	29.5	31.7	28.3	26.1
Zweibrucken AB	1132	49	7	17.6	9.6	27.2	30.0	26.7	24.4
Berlin	164	52	13	19.0	8.7	27.7	31.1	27.2	25.0
France									
Chateauroux AS	515	47	2	18.9	11.1	30.0	32.8	28.3	25.6
England									
Bentwater RAC	95	52	1	16.2	8.1	24.3	25.0	22.2	20.6
Burtonwood AB	89	53	3 W	15.9	7.9	23.8	25.6	22.2	20.0
London	82	51	0	17.7	9.5	27.2	27.8	25.0	22.8
Mildenhall RAF	33	52	0	16.6	9.1	25.7	26.7	23.9	21.7
Italy									
Aviano AB	429	46	13 E	22.3	10.2	32.5	32.8	30.0	28.3
Iceland									
Keflavik	169	64	23 W	10.8	4.4	15.2	15.6	14.4	13.3
Greenland									
Sondrestrom AB	165	67	51	10.6	9.8	20.4	20.0	17.8	16.7
Thule AB	261	77	69	4.9	4.8	9.7	13.3	10.6	9.4

It is interesting that although the addition of the European and North Atlantic stations to the 30 United States stations used in Tattelman's study[2] improved the correlations, the standard errors of estimate of the regression lines changed only slightly. The original correlations were 0.94 for $T_{1\%}$ and 0.95 for $T_{5\%}$ and $T_{10\%}$, and standard errors of estimate were 1.29°, 1.29°, and $1.37^{\circ}C$, respectively.

Temperatures estimated by all the regression curves are warmer than the actual temperatures for the three coldest locations, as can be seen in Figure 1. There is no reason to believe, however, that Eqs. (2), (3), and (4) are not valid worldwide, within the temperature range in Figure 1, with the exception that there might be a slight bias towards estimating too warm temperatures at the cooler locations.

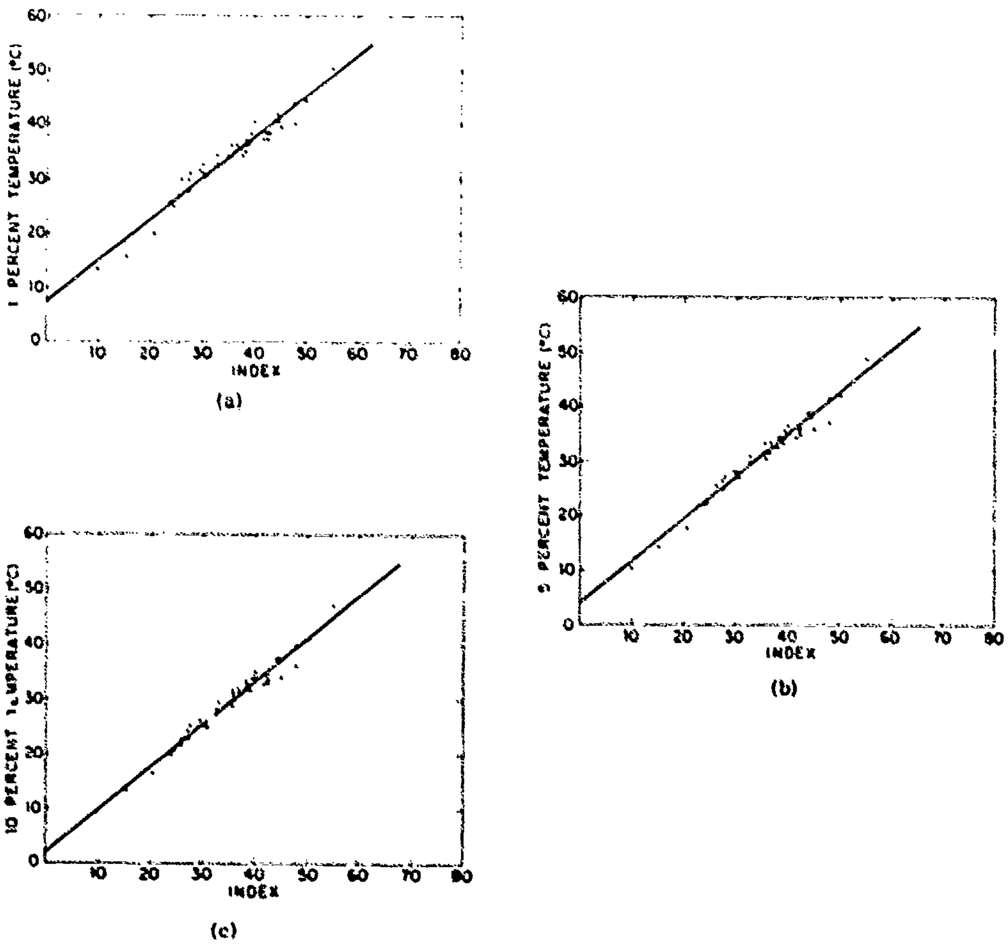

Figure 1. Percent Warm Temperature vs Index: (a) 1 percent; (b) 5 percent; (c) 10 percent.

Table 2. Comparison of Temperatures (^{o}C) Calculated from the Data and Those Estimated Using Eqs. (2), (3) and (4)

Station	Percentile	Observed Temperature	Estimated Temperature
Adrar, Algeria	1	47	49
	5	46	47
	10	45	45
El Golea, Algeria	1	44	45
	5	42	42
	10	41	41
Fort Flatters, Algeria	1	45	47
	5	43	44
	10	42	43
In Salah, Algeria	1	46	48
	5	45	45
	10	44	44
Quallene, Algeria	1	45	47
	5	44	45
	10	43	43
Belize, Br. Honduras	1	32	34
	5	32	31
	10	31	29

2.2 Cold Temperatures

Since Eq. (1) proved successful for describing warm temperature extremes, the same principle was used to estimate cold temperature extremes. A cold temperature index, I_c, is expressed by:

$$I_c = \overline{T} - (\overline{T}_x - \overline{T}_n) \quad , \tag{5}$$

where $\overline{T}$ is the mean, $\overline{T}_x$ is the mean daily maximum, and $\overline{T}_n$ the mean daily minimum temperature for the coldest month. The index was correlated with the 1-, 5-, 10- and 20-percent cold temperatures during the coldest month at 30 stations in North America, and 13 stations in Europe and the North Atlantic (provided by ETAC). The stations and pertinent data are listed in Table 3.

Table 3. List of Stations, Showing 1-, 5-, 10-, and 20-Percent Cold Temperatures (°C) during the Coldest Month. Also, mean ($\bar{T}$), mean daily range ($\bar{T}_x - \bar{T}_n$), and Index ($\bar{T} - (\bar{T}_x - \bar{T}_n)$)

Station	Alt (Ft)	Lat	Long	$\bar{T}$	$\bar{T}_x - \bar{T}_n$	Index	$T_{1\%}$	$T_{5\%}$	$T_{10\%}$	$T_{20\%}$
U.S.										
Alert	216	82 N	62 W	-32.4	5.7	-38.1	-45.0	-40.6	-38.9	-36.7
Baker Lake	30	64	96	-33.5	6.2	-39.7	-45.6	-43.9	-42.2	-39.4
Boston	[illegible]	42	71	- 1.6	7.4	- 9.0	-16.1	-11.7	- 9.4	- 6.1
Cambridge Bay	45	69	105	-35.0	5.2	-40.2	-46.7	-43.9	-42.8	-40.6
Caribou	624	47	68	-11.8	10.2	-22.0	-30.0	-25.6	-23.1	-19.7
Coral Harbor	203	64	83	-29.7	6.4	-36.1	-45.0	-41.7	-39.4	-37.2
Des Moines	938	42	94	- 7.0	9.0	-16.0	-23.9	-20.3	-17.5	-13.9
Edmonton	2219	54	114	-15.7	[illegible]	-21.1	-33.9	-29.4	-26.7	-22.8
Ennadai Lake	1065	61	101	-30.9	6.8	-37.7	-46.7	-42.2	-40.6	-37.8
Eureka	33	80	86	-36.3	5.8	-42.1	-48.3	-46.1	-44.4	-42.8
Fairbanks	547	65	147	-23.9	10.0	-33.9	-47.2	-43.9	-40.0	-33.9
Fargo	896	47	97	-14.5	10.6	-25.1	-33.9	-30.0	-27.8	-24.4
Ft. Chimo	118	58	68	-22.6	7.5	-30.1	-41.7	-37.2	-34.4	-31.7
Ft. Nelson	[illegible]	59	123	-23.2	7.2	-30.4	-41.7	-37.8	-35.0	-31.1
Ft. Smith	[illegible]	60	112	-26.1	8.8	-34.9	-44.9	-39.9	-37.2	-33.8
Frobisher	69	64	69	-25.2	6.5	-31.7	-41.3	-39.1	-37.4	-34.1
Isachsen	99	79	104	-34.8	5.4	-40.2	-47.8	-43.9	-42.2	-40.0
Minneapolis	834	45	93	-11.0	10.0	-21.0	-29.7	-25.6	-22.8	-18.9
Moose Jaw	1857	50	106	-14.6	8.8	-23.4	-33.9	-30.0	-27.8	-23.9
Mould Bay	190	76	119	-34.7	5.5	-40.2	-46.7	-43.9	-41.7	-40.0
Norman Wells	290	65	127	-28.3	7.0	-35.3	-46.7	-44.4	-41.7	-37.8
Rapid City	3162	44	103	- 5.6	13.7	-19.3	-28.6	-24.4	-21.7	-16.9
Resolute	131	75	95	-32.4	5.6	-38.0	-45.6	-42.8	-40.6	-37.8
Sachs Harbor	276	72	125	-31.1	5.0	-36.1	-44.4	-40.6	-38.9	-36.7
Salt Lake City	4220	41	112	- 2.2	10.5	-12.7	-20.0	-20.3	-12.2	- 8.9
San Francisco	8	38	122	9.1	7.8	1.3	- 1.1	1.1	2.5	4.2
Watson Lake	2248	60	129	-25.1	9.3	-34.4	-47.8	-44.4	-40.6	-34.4
Whitecourt	2430	54	116	-14.8	9.7	-24.5	-37.8	-32.2	-28.9	-23.9
Whitehorse	2216	61	135	-18.6	6.7	-25.3	-43.3	-39.4	-35.6	-30.0
Yellow-Knife	682	62	114	-28.3	7.2	-35.5	-44.4	-41.7	-39.4	-36.7
Germany										
Bitburg AB	1238	50	7 E	- 0.2	4.3	- 4.5	-12.2	- 8.3	- 6.1	- 3.9
Erding AS	1512	48	12	- 1.4	5.9	- 7.3	-16.1	-11.1	- 8.3	- 5.6
Zweibrucken AB	1132	49	7	0.3	3.3	- 3.0	-12.8	- 8.3	- 6.1	- 3.9
Berlin	164	52	13	- 0.4	4.2	- 4.6	-15.0	-10.0	- 7.8	- 4.4
France										
Chateauroux AS	515	47	2	2.9	5.8	- 2.9	-10.0	- 5.6	- 3.3	- 1.7
England										
Bentwaters RAF Stn	85	52	1	3.6	4.5	- 0.9	- 5.0	- 2.2	- 1.1	0.6
Burtonwood AB	69	53	3 W	3.6	4.9	- 1.3	- 5.0	- 2.8	- 1.1	0.6
London	82	51	0	4.5	5.8	- 1.4	- 4.4	- 1.7	- 0.6	1.1
Mildenhall RAF Stn	33	52	0	3.6	5.0	- 1.4	- 7.2	- 3.3	- 1.7	0.6
Italy										
Aviano AB	429	46	13 E	2.7	8.4	- 5.7	- 8.9	- 5.6	- 3.9	- 1.7
Iceland										
Keflavik	169	64	23 W	0.2	4.2	- 4.0	-11.7	- 7.8	- 6.1	- 3.9
Greenland										
Sondrestrom AB	165	67	51	-17.8	[illegible]	-26.7	-40.0	-34.4	-31.1	-27.2
Thule AB	241	77	69	-23.8	8.3	-32.1	-37.2	-35.0	-33.3	-30.6

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The following regression lines for the 1, 5, 10 and 20 percent temperatures were found by the method of least squares:

$$T_{1\%} = 1.077\ I_c - 6.798 \tag{6}$$

$$T_{5\%} = 1.084\ I_c - 3.079 \tag{7}$$

$$T_{10\%} = 1.080\ I_c - 0.788 \tag{8}$$

$$T_{20\%} = 1.061\ I_c + 1.848 \tag{9}$$

Linear correlations are 0.98 for $T_{1\%}$, 0.99 for $T_{5\%}$ and $T_{10\%}$ and 0.995 for $T_{20\%}$. The standard errors of estimate are 2.97°, 2.57°, 2.03° and 1.51°C, respectively. Scatter diagrams and least square curves are shown in Figure 2.

Table 4 shows a comparison of observed and estimated temperatures at five North American stations not used in the regression analysis. Except for the New Orleans data, estimated and actual temperatures compare quite favorably. However, all the Miami and New Orleans estimated temperatures are colder than observed, and several other points at the warm end of all four regression curves are warmer than the estimated temperature. Consequently, there seems to be a slight bias towards estimating too cold a temperature at the warmer locations within the limits of Figure 2.

Although excellent results were obtained with Eqs. (1) and (5), it was decided to determine if these equations could be improved by using a coefficient other than 1 for the temperature range. This was accomplished by testing the equation

$$I = T - a\,(T_x - T_n) \tag{10}$$

for different values of a at each percentile temperature. It was found that the optimum values of a are 1.3 for $T_{1\%}$, 1.3 for $T_{5\%}$, 1.0 for $T_{10\%}$ and 0.7 for $T_{20\%}$. The resulting reductions in the standard errors of estimate for $T_{1\%}$, $T_{5\%}$, and $T_{20\%}$, however, are insignificant and do not justify using several different values of a.

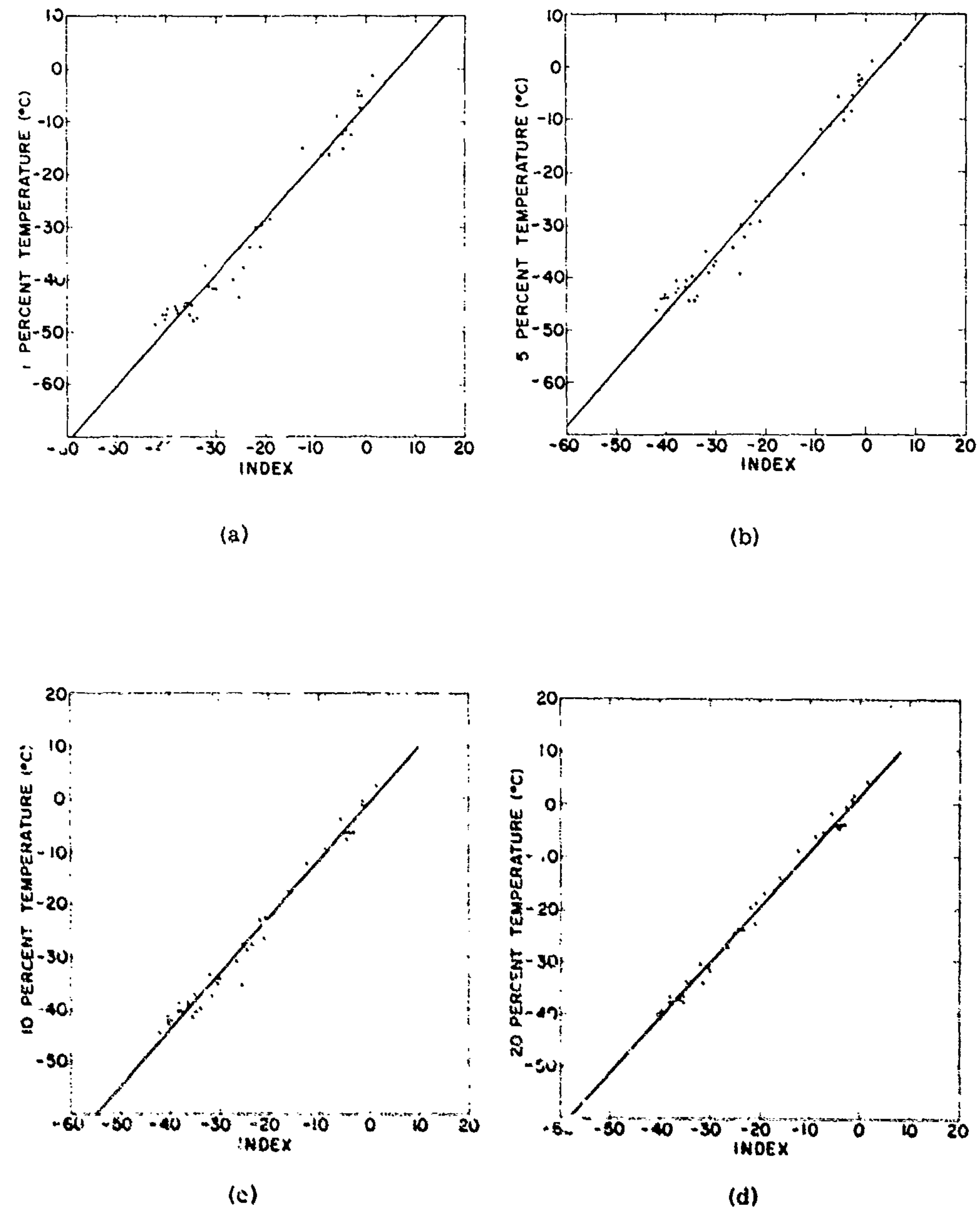


Figure 2. Percent Cold Temperature vs Index: (a) 1 percent; (b) 5 percent; (c) 10 percent; (d) 20 percent.

Table 4. Comparison of Temperatures (°C) Calculated from the Data and Those Estimated Using Eqs. (6), (7), (8) and (9)

Station	Percentile	Observed Temperature	Estimated Temperature
Churchill, Canada	1	-40	-43
	5	-38	-40
	10	-37	-38
	20	-34	-34
Goose Bay, Canada	1	-33	-31
	5	-29	-28
	10	-27	-25
	20	-24	-22
Montreal, Canada	1	-27	-25
	5	-22	-22
	10	-19	-19
	20	-17	-16
Miami, U.S.	1	6	4
	5	10	8
	10	12	10
	20	16	12
New Orleans, U.S.	1	1	- 5
	5	4	- 2
	10	6	0
	20	8	2

3. MAPPING OF THE PERCENTILE TEMPERATURES

A publication by the British Meteorological Office[10] and one by the USAF, Environmental Technical Applications Center[11] were used to derive warm and cold indices. These provided data for approximately 2,000 different stations in the Northern Hemisphere. Indices were calculated for the warmest and coldest months for each location and were plotted on two AFGL Polar Equal-Area Maps of the Northern Hemisphere, one for the warm index and one for the cold index. The plot of each index included information on period of record (< 5 years, < 10 years or ≥10 years) and station altitude (≥1524 m or 5,000 ft, ≥3048 m, and ≥4572 m) to

10. Meteorological Office (1966) Tables of Temperature, Relative Humidity and Precipitation for the World, Part I-VII, Her Majesty's Stationery Office, London.

11. USAF Environmental Technical Application Center (1971) Worldwide Airfield Climatic Data, Vol. I-X; also published by U. S. Naval Weather Service entitled U. S. Naval Weather Service World-wide Airfield Summaries.

aid in the analyses. Each percentile map was analyzed for the temperatures associated with the appropriate indices as indicated in Tables 5 and 6. The 1-, 5-, and 10-percent high temperature maps are shown in Figures 3, 4, and 5, and the 1-, 5-, 10-, and 20-percent low temperatures maps are shown in Figures 6, 7, 8, and 9, respectively.

Table 5. Index Corresponding to Temperature Equalled or Exceeded during 1, 5, and 10 Percent of the Warmest Month

Temperature (°C/°F)	Probability (%)		
	1	5	10
10/50	3.2	7.5	10.1
15/59	9.8	14.0	16.5
20/68	16.4	20.5	22.9
25/77	23.0	27.0	29.3
30/86	29.6	33.5	35.7
35/95	36.2	39.9	42.1
40/104	42.9	46.4	48.5
45/113	49.5	52.9	54.9
50/122	56.1	59.3	61.3

Table 6. Index Corresponding to Temperature Equalled or Colder during 1, 5, 10 and 20 Percent of the Coldest Month

Temperature (°C/°F)	Probability (%)			
	1	5	10	20
10/ 50	15.8	12.1	10.0	7.9
5/ 41	11.1	7.5	5.3	3.2
0/ 32	6.4	2.9	0.7	- 1.6
-5/ 23	1.7	- 1.8	- 4.0	- 6.3
-10/ 14	- 3.0	- 6.4	- 8.6	-11.1
-15/ 5	- 7.7	-11.0	-13.2	-15.8
-20/ -4	-12.4	-15.6	-17.9	-20.6
-25/-13	-17.0	-20.2	-22.5	-25.3
-30/-22	-21.7	-24.8	-27.2	-30.0
-35/-31	-26.4	-29.4	-31.8	-34.8
-40/-40	-31.0	-34.0	-36.5	-39.5
-45/-49	-35.7	-38.6	-41.1	-44.2
-50/-58	-40.3	-43.2	-45.8	-48.9
-55/-67	-45.0	-47.8	-50.4	-53.6
-60/-76	-49.7	-52.4	-55.0	-58.3
-65/-85	-54.3	-57.0	-59.6	-63.0

One of the most difficult aspects of this analysis is the extreme temperature variations in mountainous areas. For example, strong gradients are common between nearby stations at different elevations, and extremes at mountain locations may not be representative. Consequently, elevations generally greater than 5,000 feet are hatched on the maps to alert the user to the presence of mountainous terrain and resulting large temperature variations with elevation. Isotherms over these areas are dashed to indicate their uncertain validity. Dashed lines are truncated where there are insufficient data for analysis, and resumed where there are sufficient data. It should be understood that beyond the truncation, an imaginary isotherm remains within that hatched area until it is resumed elsewhere within or at the edge of the hatched area.

Underlined values are used to indicate percentile temperatures at island locations. Most island locations have only one station. However, on islands with more than one station, the most extreme temperature is shown. Underlined values at inland locations are used to identify the highest (lowest) temperature within an isotherm where appropriate.

For convenience, isotherms were extended short distances over water areas, but this should not be considered an accurate analysis of temperatures over the water surface.

4. DISCUSSION OF THE TEMPERATURE MAPS

4.1 Warm Temperatures

The hottest part of the Northern Hemisphere (and the world) lies in the interior of northern Africa eastward to India. Large areas attain temperatures of 45°C (113°F) or greater 1 percent of the time, with several locations having 1 percent temperatures of 49°C (120°F). The hottest of these locations by less than one degree C, is Araouane, French Sudan. Although other nearby parts of northwest Africa may be even hotter, the area is so sparsely populated that temperature records are not available.

The hottest part of North America is found in the southwestern United States adjacent of the junction of California, Nevada and Arizona. This area, which includes Death Valley, reaches temperatures in excess of 45°C 1 percent of the hottest month, with several stations having 1 percent temperatures of 46°C (115°F).

4.2 Cold Temperatures

The coldest areas in the Northern Hemisphere are found in eastern Siberia and on the Greenland ice cap. However, the 1 percent cold temperature of -70°C

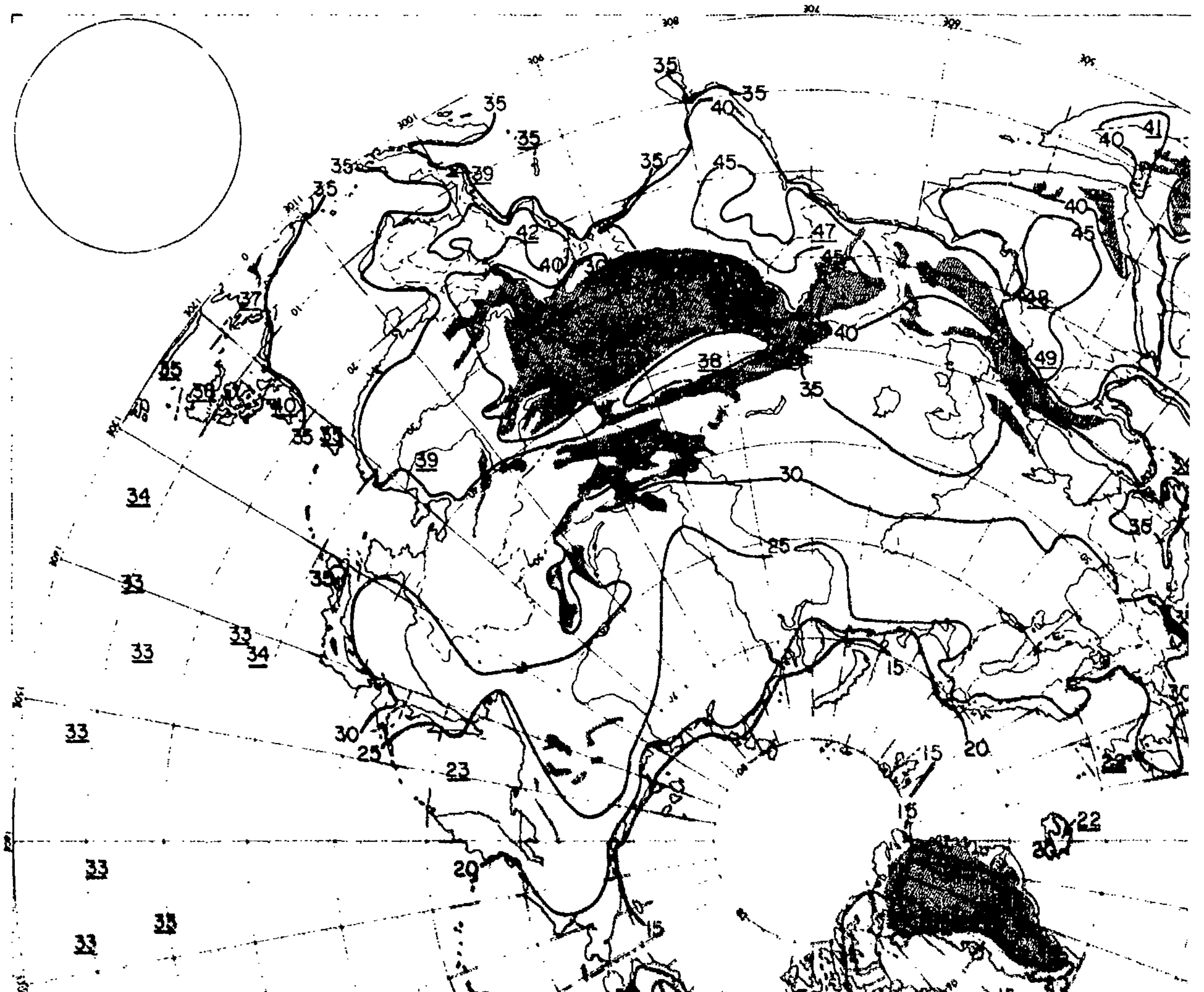
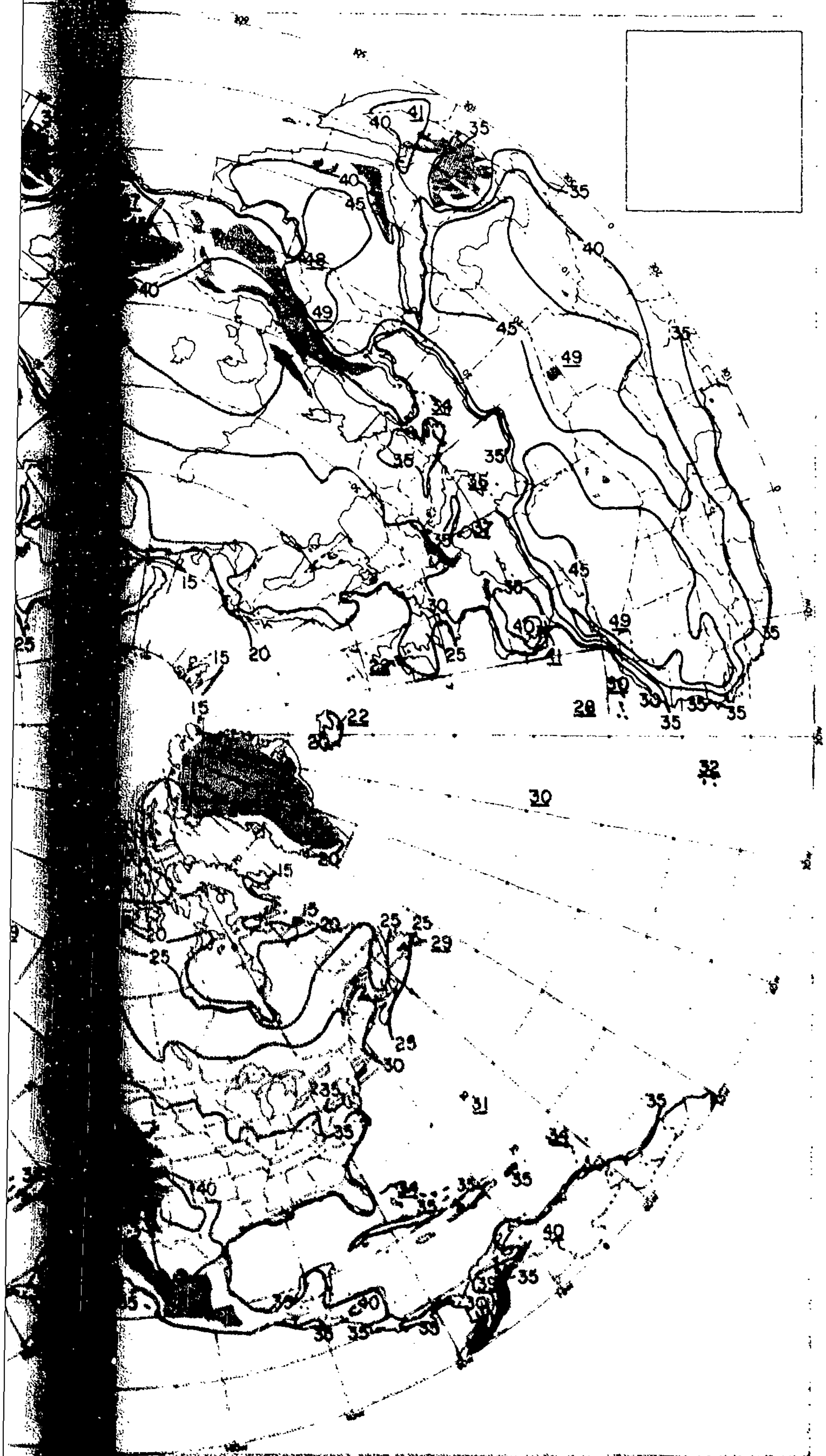


Figure 3. Temperature Equalled or Exceeded 1 Percent of the Time during the Warmest Month



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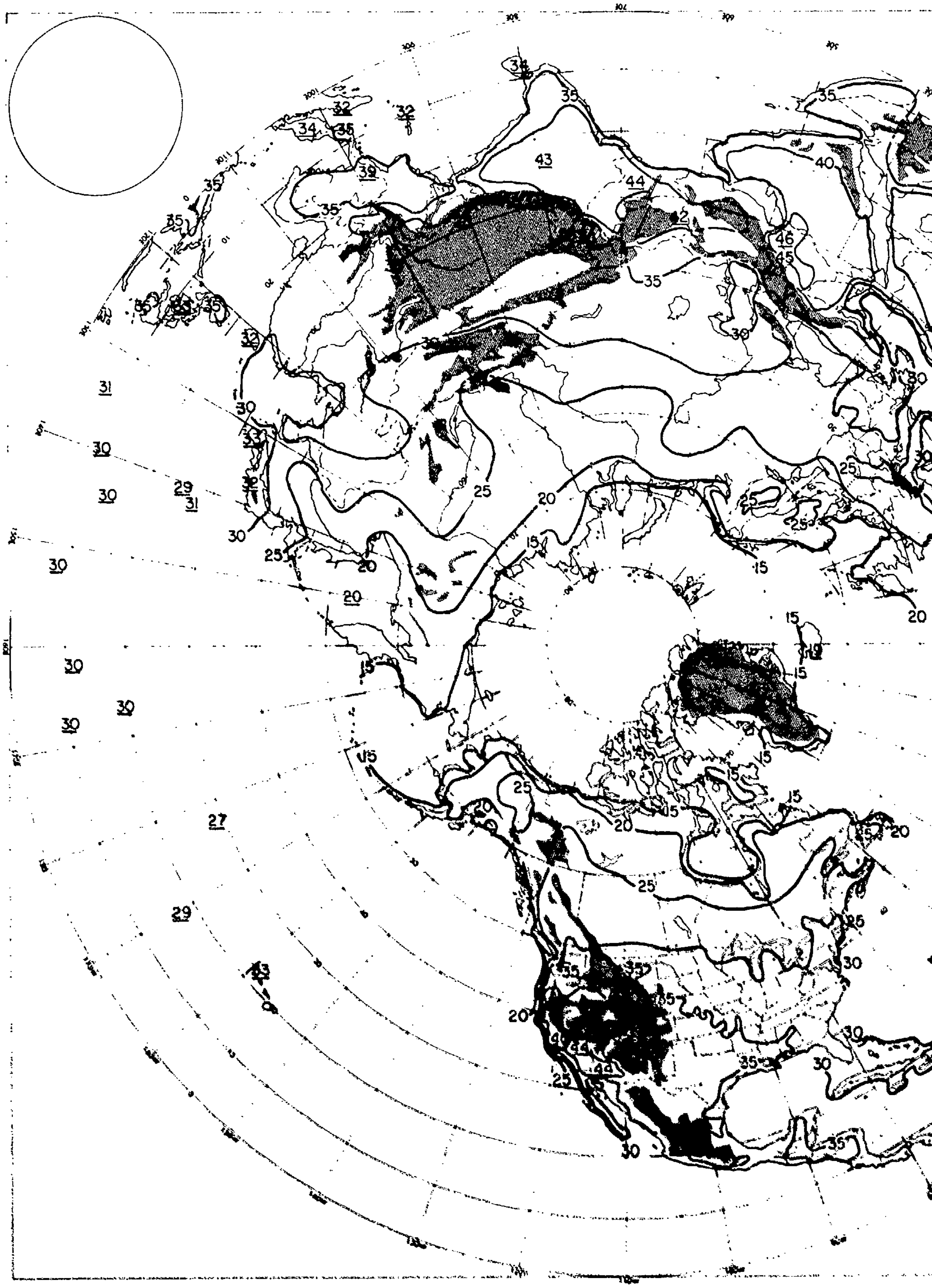
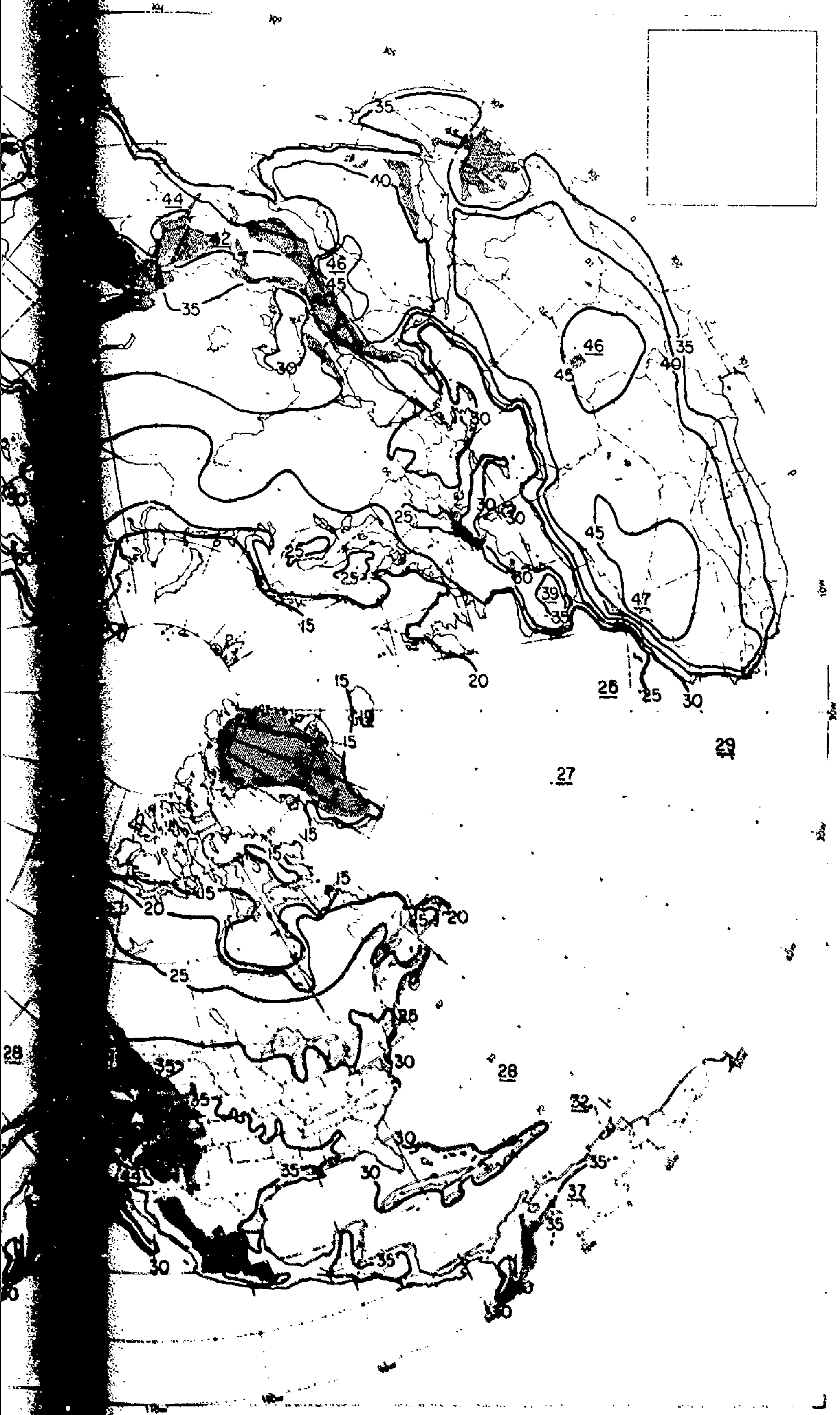


Figure 4. Temperature Equalled or Exceeded 5 Percent of the Time during the Warmest Month



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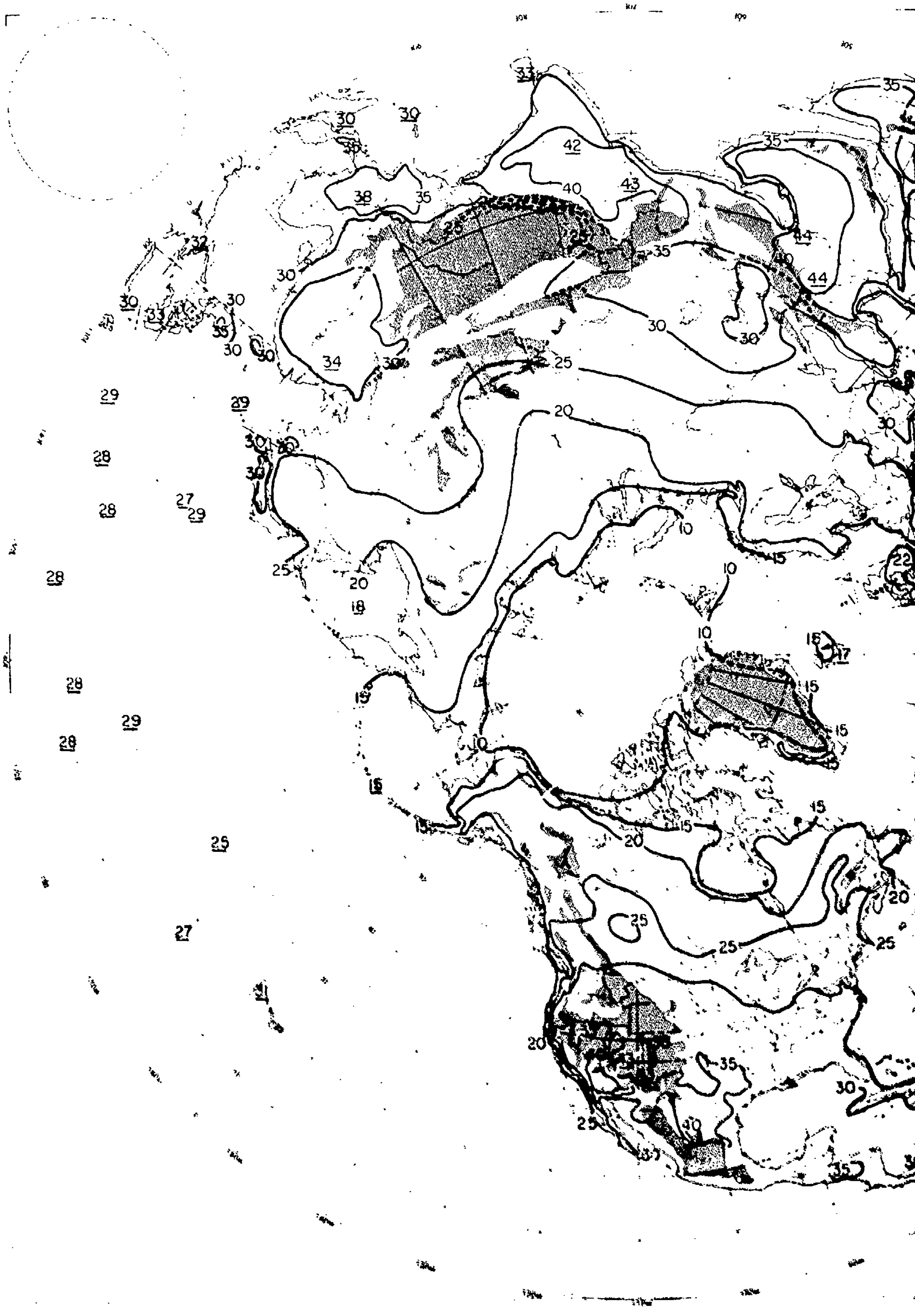

Figure 5. Temperature Equalled or Exceeded 10 Percent of the Time during the Warmest Month

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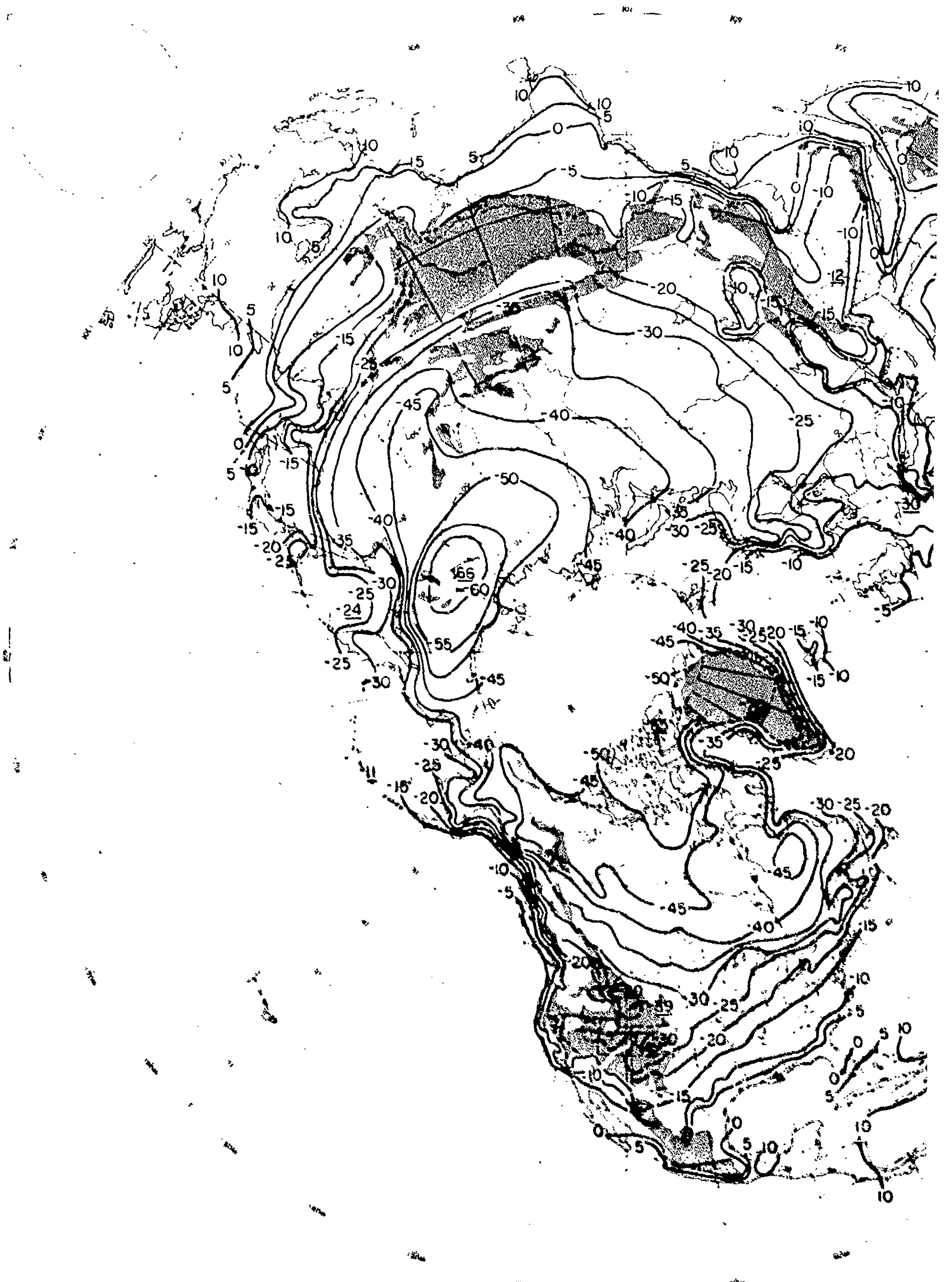
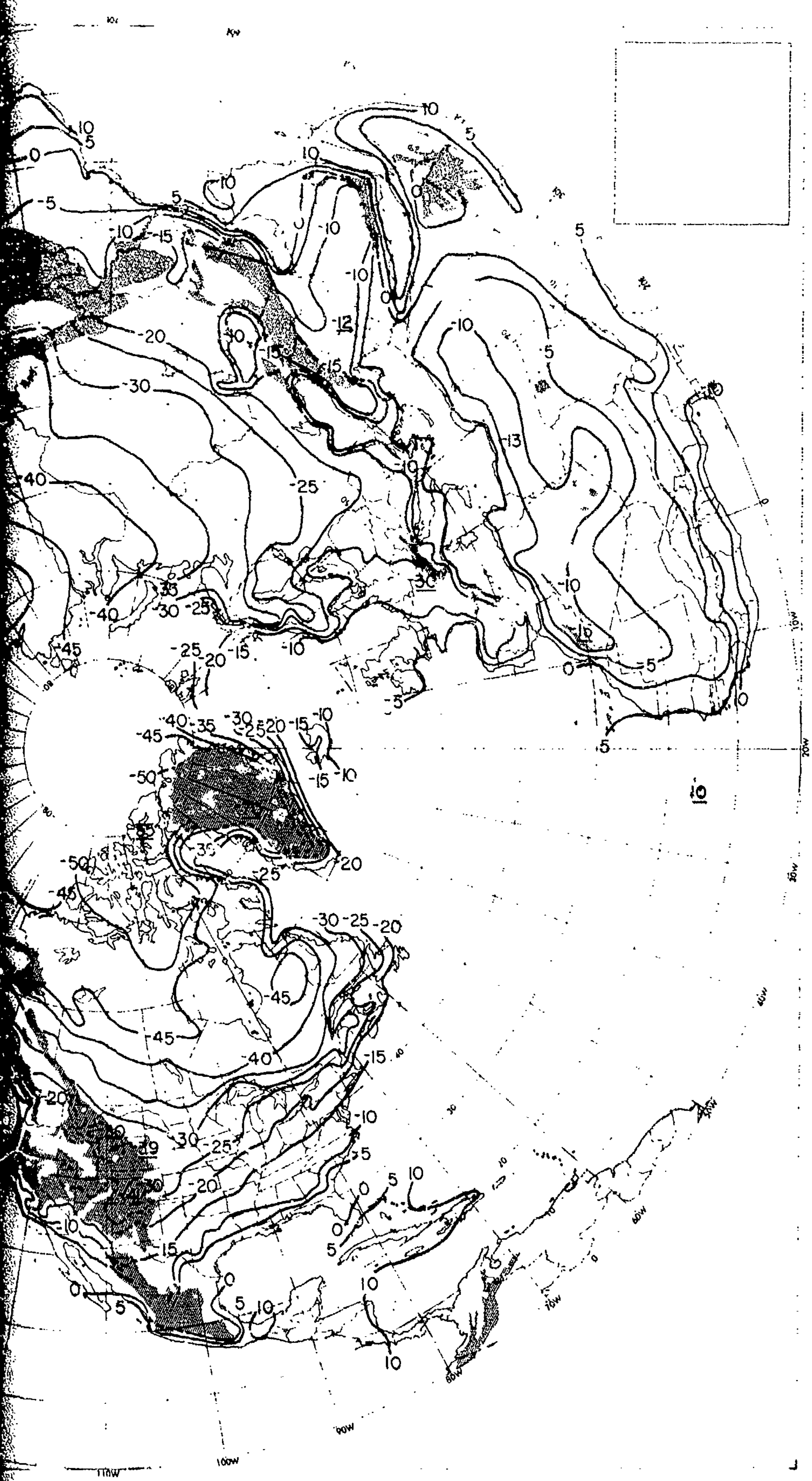


Figure 6. Temperature Equalled or Colder 1 Percent of the Time during the Coldest Month



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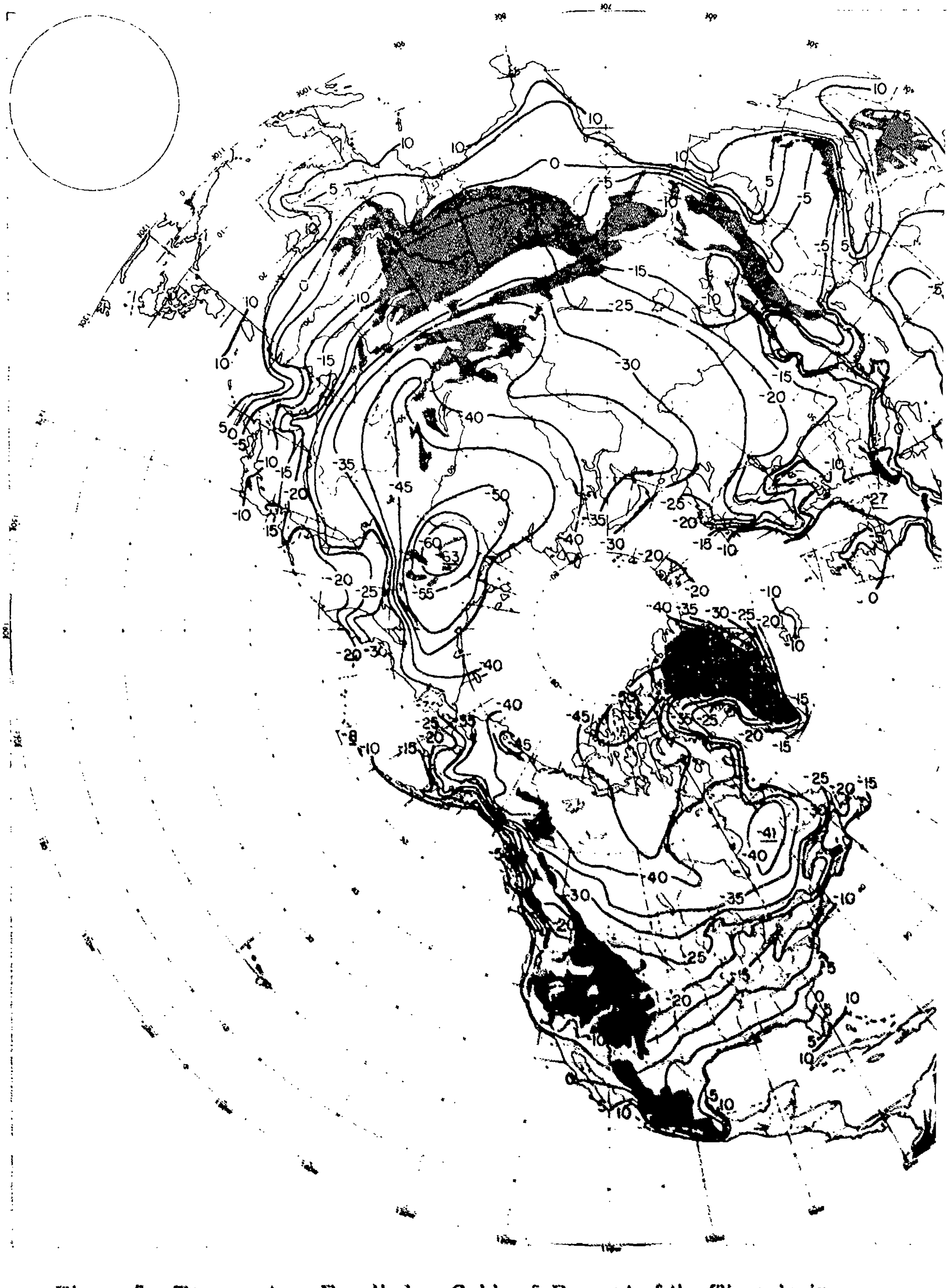
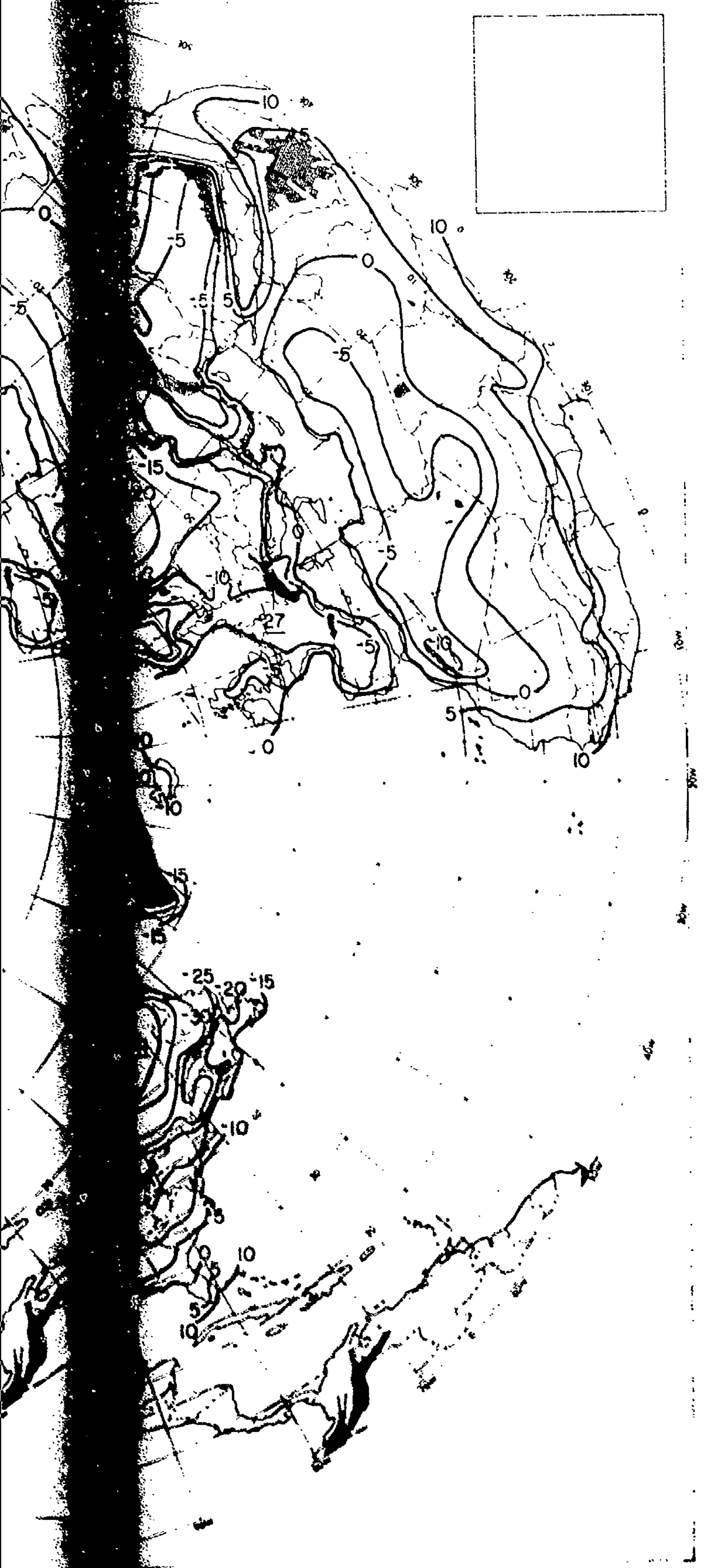


Figure 7. Temperature Equalled or Colder 5 Percent of the Time during the Coldest Month



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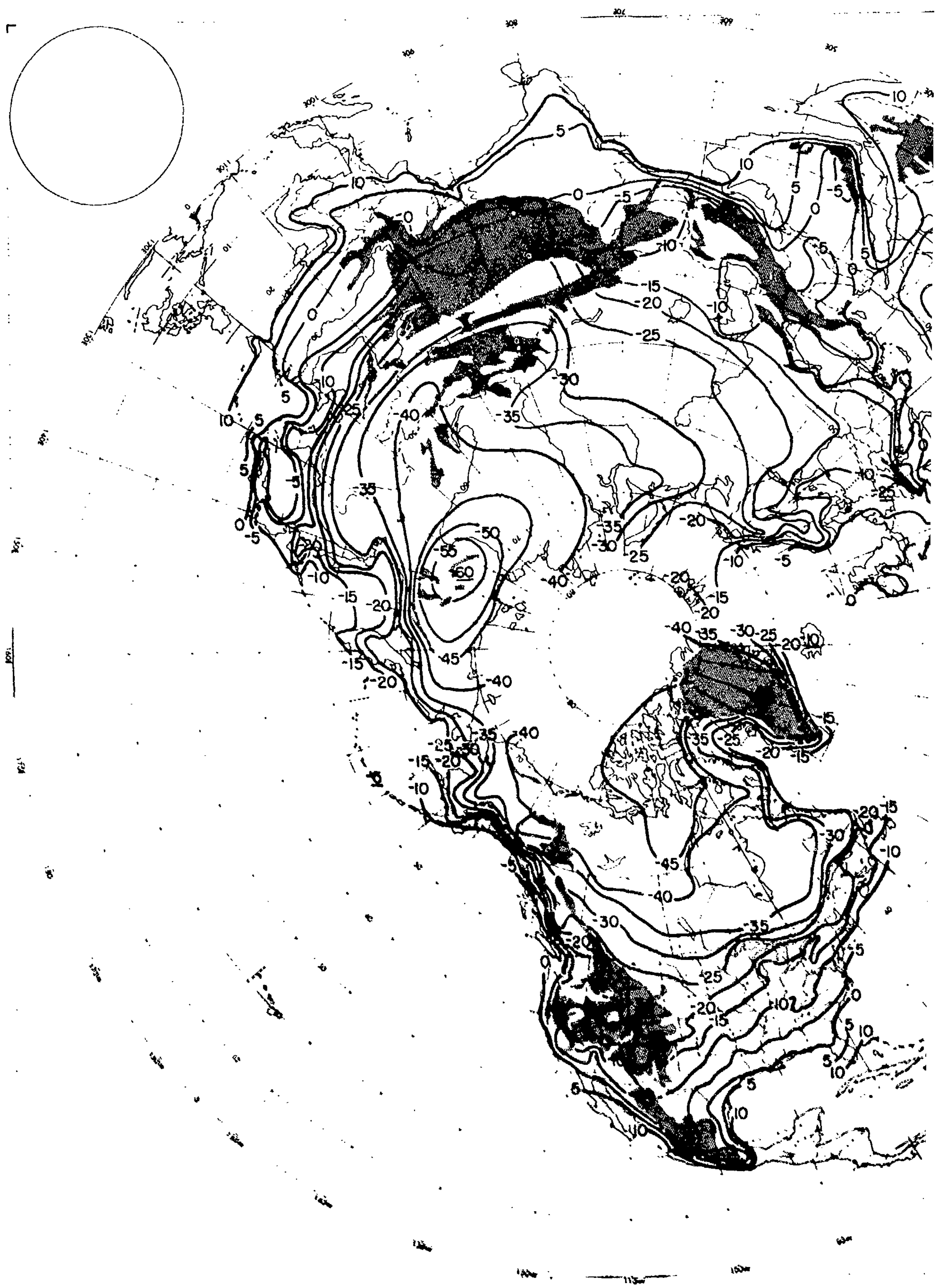
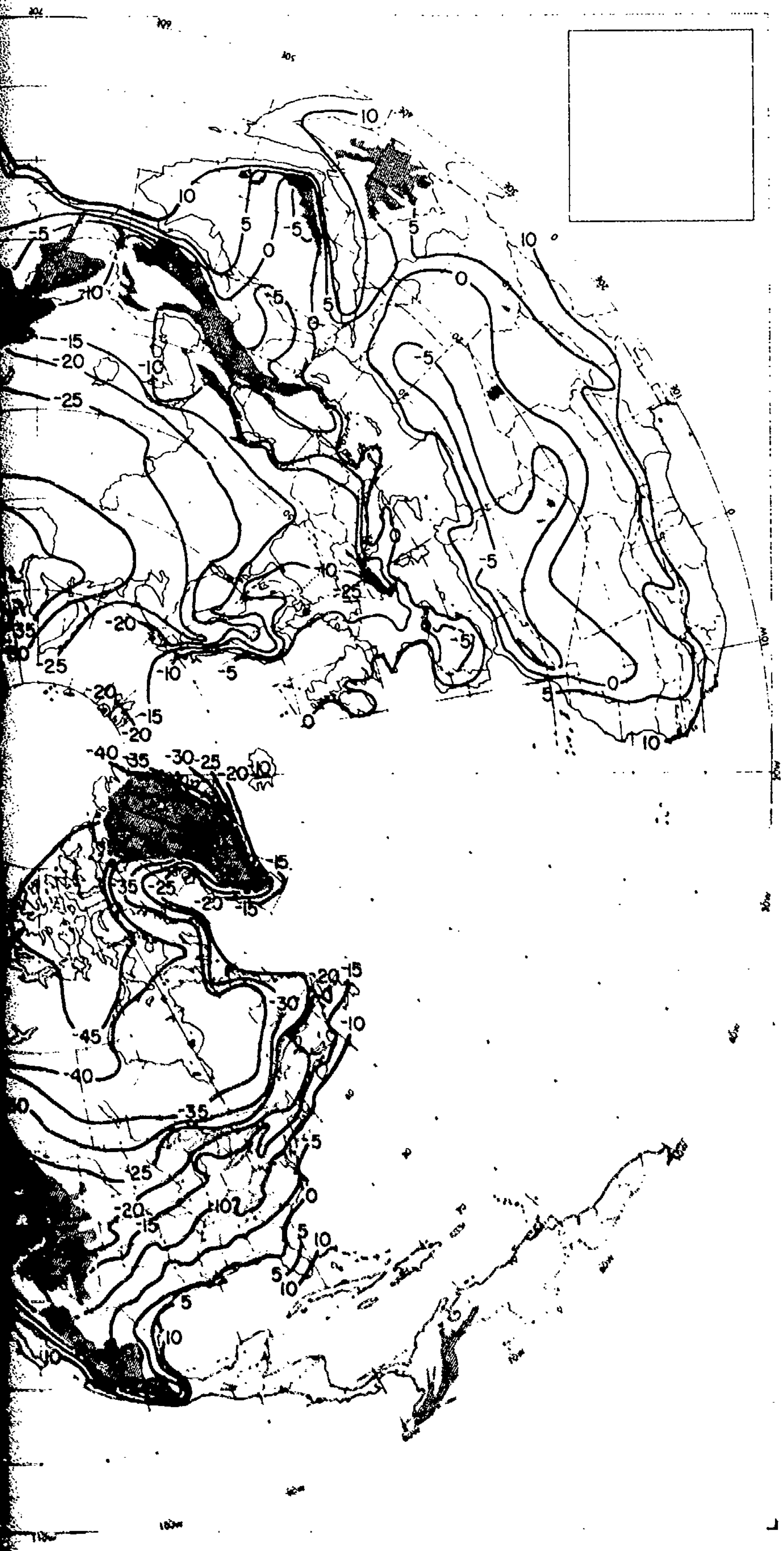


Figure 8. Temperature Equalled or Colder 10 Percent of the Time during the Coldest Month



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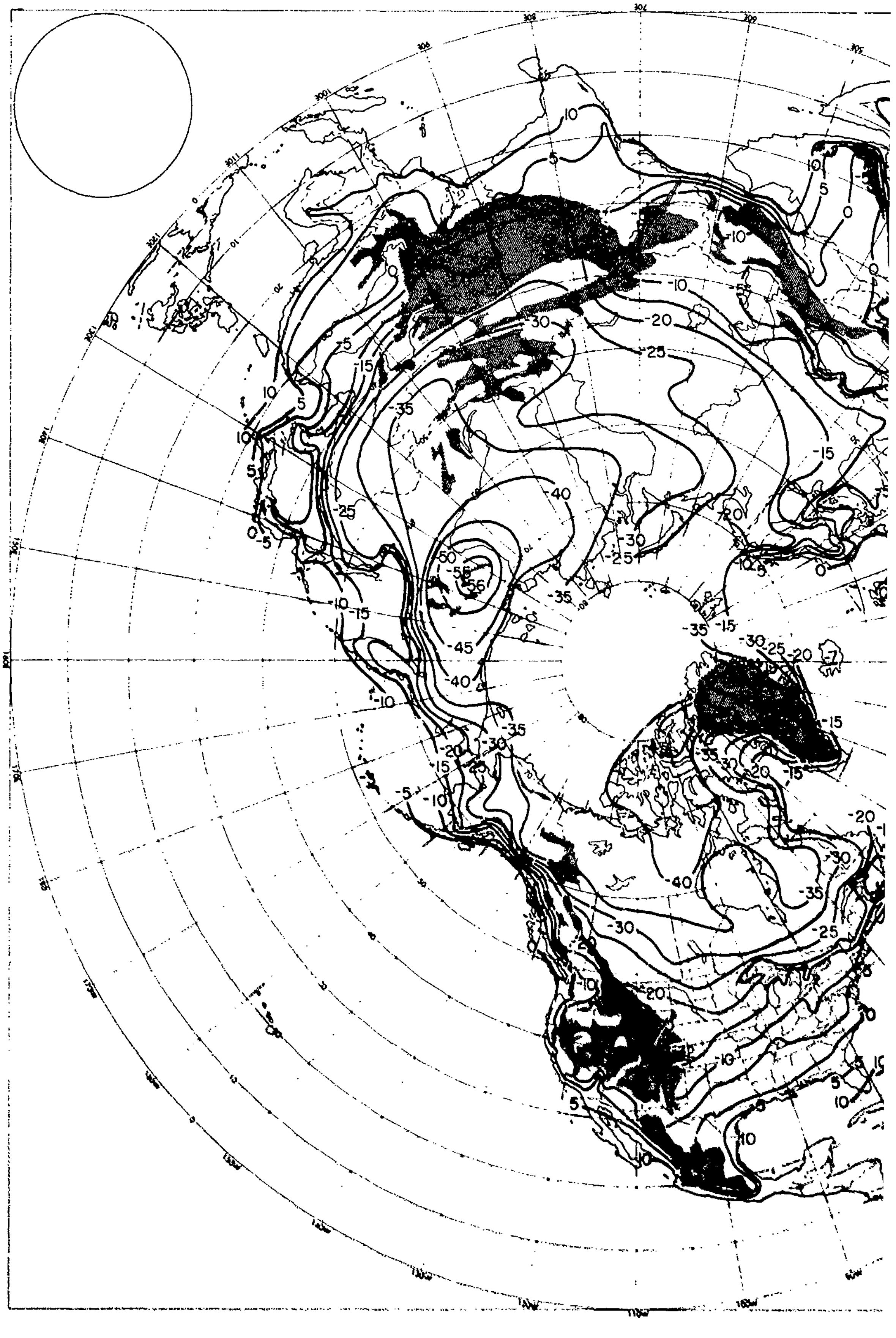
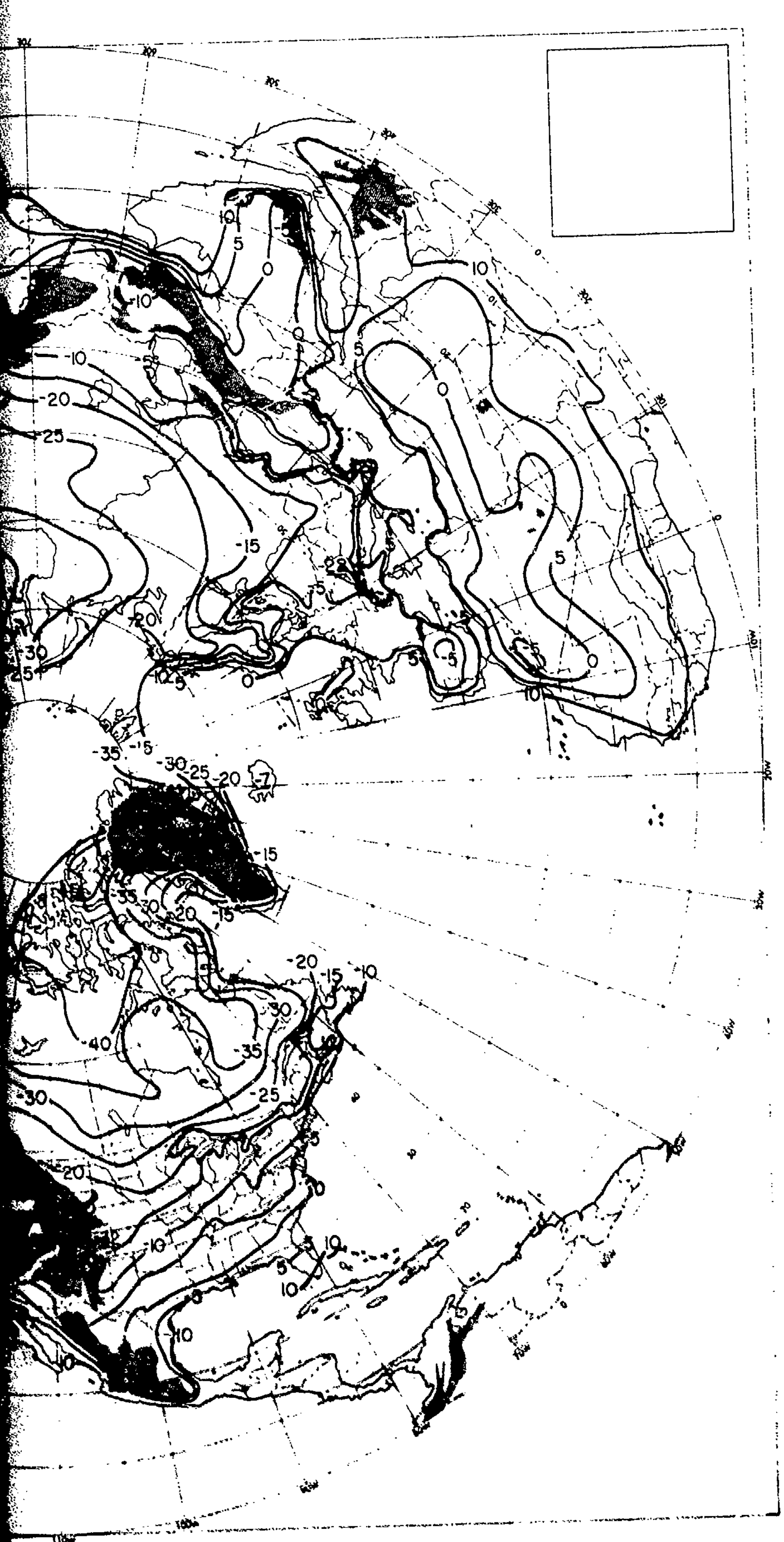


Figure 9. Temperature Equalled or Colder 20 Percent of the Time during the Coldest Month



rcent of the Time during

2

(-94°F) at Eismitte in central Greenland (see Figure 6) was calculated on the basis of one year of observations taken during an expedition and should be considered tentative. The coldest temperatures, based on a long period of record, occur at Verkhoyansk, Siberia. Its 1 percent temperature is shown as -66°C (-87°F) in Figure 6.

The coldest part of the North American continent is Ellesmere Island, where temperatures as low as -55°C (-67°F) occur 1 percent of the time during the coldest month. Snag, Yukon Territory, where North America's lowest temperature, -63°C (-81°F), was recorded, has a 1 percent cold temperature of -49°C (-56°F).

5. FURTHER CONSIDERATIONS

The temperatures on which this study is based were observed within standard meteorological instrument shelters. As a result, they approximate temperatures of the free air about 5 or 6 ft above the ground. The high temperatures described herein normally will be encountered during periods of strong sunshine and fairly light winds. Similarly, low temperatures generally will be encountered during nights with clear skies and little or no wind. The ground can attain temperatures from 15° to 30°C higher and 5° to 10°C lower than that of the free air, depending upon radiation, conduction, wind, and turbulence.

Since the design philosophy for temperature extremes, as adopted for this report, is based on the probability of being exceeded during the warmest (coldest) month of the year, the number of hours this temperature is encountered during all other months will be smaller than in the warmest (coldest) month. Also, the annual risk will be roughly one tenth of that shown for the warmest (coldest) month.

It should be noted that the warmest (coldest) month is not necessarily the same for each station. This fact, however, does not alter the desired concept of percentage of time (risk) of inoperability for design.

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